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Counting "exotics"

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An introduced or exotic species is commonly defined as an organism accidentally or intentionally introduced to a new location by human activity (Williamson 1996; Richardson et al. 2000; Guo and Ricklefs 2010). However, the counting of exotics is often inconsistent. For example, in the US, previously published plant richness data for each state are only those either native or exotic to the US (USDA and NRCS 2004), not actually to the state. Yet, within-country (e.g., among states, counties) species introductions which form "homegrown exotics" (Cox 1999) or "native invaders" (Simberloff 2011) are undoubtedly numerous. The growing human population and associated activity increase species introductions at all levels, both international and internal but to date intercontinental species introductions have always been the focus. Those species introduced among neighboring areas are often unnoticed but they are actually far more frequent due to the proximity and environmental similarities. Many domestic exotic plant species exhibit high invasiveness such as *Spartina alterniflora* (smooth cordgrass; introduced from the east coast to California) and *Molothrus ater* (brown-headed cowbird; introduced from the Great Plains to California).

How widespread is the mismatch between definition and practice? It varies among countries and taxonomic groups. Based on the published records of plant introductions, virtually all the large countries in the world such as China, Canada, Russia, India, Australia, and the United States have not included domestic exotics in counting exotic richness in internal units (e.g., states, provinces, counties; but see Kartesz 2010).

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In other words, the national boundaries are used to count exotics. This is because, for many taxonomic groups, species introductions among internal administrative units are rarely monitored. The effect of using national boundary to count exotic species becomes greater when the internal units become smaller. For example, within California, detailed records show many native species (to some parts of the state) have been naturalized in other parts of the state (e.g., Hickman 1993; S. Norman, pers. commun.). In contrast, as the focal area becomes larger, the exotic species pool becomes smaller (at the global scale, there are no exotic species).

Using boundaries larger than the concerned internal units could drastically underestimate the exotic richness (and overestimate native species richness). The native species richness automatically changes when the "exotic" species richness has been correctly estimated. After the correction is done, it is critical to re-examine and evaluate previously reported diversity patterns, the relationships between the natives and exotics, and the relationships of species richness in different categories with other biotic, social, and physical variables.

Also, there are discrepancies in domestic species introductions among taxonomic groups. For example, domestic species introduction of fishes within the US but among drainages (not states) usually have good records (e.g., Fuller et al. 1999). Therefore, comparing invasion patterns for different groups needs to take this into account.

In short, counting exotics correctly is critical in invasion biology, conservation, and biogeography. Similar to international species invasions, internal species introductions also have serious ecological and environmental consequences thus pose significant social-economic problems (Cox 1999). For example, as with foreign exotics (Lockwood and McKinney 2001), internal species introductions also homogenize local, state, and national floras and thus lead to similar ecological/social consequences. Indeed, internal species introductions apparently have a greater homogenizing effect than external introductions for plants and fishes (McKinney 2005) and mammals (Spear and Chown 2008).

To provide quality information for more effective management, close monitoring of internal species introductions among states (or provinces especially in large countries) is urgently needed. Public education and policy/management decisions should be in place. Domestic species introductions, for whatever reason (e.g., market-based trade and travel or accidental), should be minimized, especially if some of the species may be highly invasive. Other actions may include: (1) checking local seed/plant companies and nurseries regarding their sources, (2) monitoring major transportation ports/hubs, and (3) using truly local species (not those native only to the US but those native to the immediate vicinity) for restoration. At present, such practice and/or regulations either do not exist or are minimal. Indeed, identifying species introduced across states or provincial borders is challenging as we need to separate them from natural migrants (not "exotics" by definition) for various reasons. However, because of the proximity and unprecedented and increasing within-country traffic, human induced species introductions should be reduced to the minimum level possible.

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